

Applications of Plasma Spectroscopy to the Study of High Energy Density Matter

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The development in recent years of novel high energy laser, pulsed power, and other plasma sources has resulted in a greatly expanded variety of high energy density plasma environments being made accessible to laboratory study. Furthermore, many of these sources are directly aimed at solving applied problems in areas as diverse as inertial fusion, x-ray lithography, and nuclear weapons science, to name a few. These factors have motivated efforts to improve our understanding of the basic physics underlying high energy density plasmas. Significant progress has been made in the specific area of plasma spectroscopy, which has long played a leading role in the diagnosis and study of such plasmas.

In this talk, we review progress in the field of plasma spectroscopy as applied to high energy density plasmas, and discuss several important outstanding problems. A survey of the field is naturally split into two areas: "basic" physics issues and the study of applied "integrated" problems. Examples of the former include spectral lineshapes, plasma kinetics, and atomic structure. Examples of "integrated" problems include plasma spectral modeling, production of radiation dominated environments, and certain aspects of inertial fusion implosions.

Great progress has been made in recent years in both the basic and "integrated" areas. Examples of important advances in basic plasma spectroscopy include the development of advanced generalized line broadening codes, novel methods of calculating atomic structure, and new treatments of LTE opacity. Experimental techniques relying on relatively uniform (in density and temperature) radiatively heated foils have been developed to serve as "laboratory" for testing our understanding of some of these basic plasma spectroscopy issues, for both the LTE and NLTE cases. In parallel with advances in high energy laser and other drivers, sophisticated diagnostics such as high resolution framing and streak cameras and monochromatic imagers have been developed, which have greatly increased the quality and quantity of available experimental data.

Significant progress has also been made in the "integrated" areas. For example, sophisticated plasma spectral diagnostics are now routinely applied to systems of applied interest such as inertial fusion implosions, ultra-short pulse laser produced plasmas, and long-scalelength, low density plasmas. The high quality measurement techniques mentioned above are of course of particular importance in diagnosing such "integrated" experiments. Significant progress has also been made in developing simulation codes capable of modeling the hydrodynamic behavior and radiative properties of the high energy density plasmas used in these experiments.

In the near future challenging questions in applied areas of high energy density physics will necessitate further advances in plasma spectroscopy. For example, improvements in the modeling of spectral emission from dense plasmas are needed, particularly in the area of spectral lineshapes and dense plasma behavior. An improved treatment of NLTE phenomena in radiation-hydrodynamic simulation codes may also be required. In the areas of inertial fusion and weapons science, the need to consider detailed hydrodynamic stability and other issues may well require the development of spectroscopic diagnostics with improved spectral, temporal, and spatial resolution.

With the advent of a host of compact short pulse laser and other plasma sources as well as several newly completed larger ICF related facilities, the next few years promise to be a fertile period for plasma spectroscopy. Of particular interest is the proposed National Ignition Facility (NIF), which will motivate research in a number of plasma spectroscopy related areas. Accordingly, in addition to the topics described above, some longer term spectroscopy issues and suggested directions for future research will also be discussed.

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